SCIENTIFIC ARTICLE

Anatomical Study of the A1 Pulley: Length and Location by Means of Cutaneous Landmarks on the Palmar Surface

Haroldo J. Fiorini, MD, João B. G. Santos, PhD, Celso K. Hirakawa, MD, Edson S. Sato, MD, Flávio Faloppa, PhD, Walter M. Albertoni, PhD

Purpose The objectives of this study were to evaluate palmar surface parameters to identify the exact location of the proximal edge of the flexor tendon A1 pulley relative to the digital palmar crease of the index, middle, ring, and little fingers and to evaluate the length of this pulley.

Methods We studied 280 fingers on 70 hands from 35 fresh human cadavers, initially by measuring the distance between the digital-palmar and proximal interphalangeal creases (measure A), followed by dissection of the fingers and measurement of the distance between the proximal edge of the A1 pulley and the digital-palmar crease (measure B) and the length of the A1 pulley (measure C). We carried out statistical analysis using Hotelling's multivariate T^2-test and the paired-samples *t*-test.

Results We found no statistically significant difference between measures A and B in each finger ($p > .05$). The mean lengths, in tenths of millimeters, were as follows: measure A: index finger 22.0 mm, middle finger 24.4 mm, ring finger 22.0 mm, and little finger 17.9 mm; measure B: index finger 21.9 mm, middle finger 24.2 mm, ring finger 22.3 mm, and little finger 18.1 mm. The average lengths of the A1 pulley were: index finger 9.8 mm, middle finger 10.7 mm, ring finger 9.6 mm, and little finger 8.1 mm.

Conclusions The distance between the digital-palmar and proximal interphalangeal creases may be used as a cutaneous landmark on the palmar surface for the exact location of the proximal edge of the A1 pulley in the palm of the hand, thereby ensuring greater safety in surgical procedures such as percutaneous release of trigger finger. *(J Hand Surg 2011;36A: 464–468. Copyright © 2011 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Anatomy, cadaver, hand, tendons, trigger finger disorder.

In hand practice, a common pathology that affects the flexor pulley system is trigger finger. A growing number of studies recommend percutaneous release of the A1 pulley, using a needle or push knife.[1–5] It is therefore important to establish parameters on the palmar surface for locating the A1 flexor pulley to improve

From the Departamento de Ortopedia e Traumatologia, Universidade Federal de São Paulo, São Paulo, Brazil.

The authors are indebted to Professor Doctor Carlos Augusto Pasqualucci, Director of the Death Verification Service of the Capital at the University of São Paulo (SVOC-USP), for collaboration with the study. He authorized dissection of the cadavers at the SVOC-USP, without which this study would not have been possible. This work was approved by the Research Ethics Committee of the Universidade Federal de São Paulo. Cadavers were obtained from the Death Verification Service of the Capital–São Paulo (SVOC).

Received for publication January 26, 2010; accepted in revised form November 23, 2010.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: Haroldo J. Fiorini, MD, Departamento de Ortopedia e Traumatologia, Universidade Federal de São Paulo, Rua Borges Lagoa, n 783, 5 andar, Sao Paulo 040-38-032, Brazil; e-mail: haroldofjr@terra.com.br.

0363-5023/11/36A03-0014$36.00/0
doi:10.1016/j.jhsa.2010.11.045

the chances of a successful procedure and reduce the risk of complications.

In 1958, Lorthioir[6] used the estimated proximal palmar crease as the proximal edge of the A1 pulley in the index finger and the distal palmar crease as the proximal edge of the A1 pulley in the middle, ring, and little fingers. In 1992, Lyu[7] used surface landmarks similar to those employed by Lorthioir, except for the middle finger, where the author found that the proximal edge of the A1 pulley was located midpoint between the proximal and distal palmar creases.

Barton[8] in 1969, Schneider and Hunter[9] in 1982, and Strauch and Moura[10] in 1985 linked the proximal edge of the flexor pulleys with the metacarpophalangeal joints of the fingers. In 1997, Nagoshi et al[11] stated that the proximal edge of the A1 pulley is located approximately 5 mm distal from the proximal palmar crease of the index finger and a few millimeters distal from the distal palmar crease of the middle, ring, and little fingers. Dunn and Pess[4] in 1999 found that the proximal edge of the A1 pulley was located, on average, 20 mm proximal to the digital-palmar crease of the fingers. In 2007, Jongjirasiri[12] linked the proximal edge of the A1 pulley with the central tip of the metacarpal head.

Despite numerous descriptions linking the fingers' flexor pulleys to palmar surface landmarks, most authors related the A1 pulley to fixed or imprecise numerical parameters, making their use unfeasible in populations with different anthropometric measures.

In 2001, Wilhelmi et al[13] demonstrated that the distance between the digital-palmar and proximal interphalangeal creases corresponded to the distance of the proximal edge of the A1 flexor pulley from the palmar digital crease in the fingers.

In view of the existence of ethnic and anthropometric differences between populations of different countries and the fact that hand size, as well as the distance between the palmar creases and the length of finger pulleys, may vary from one population to another, we sought to verify whether the relationship found by Wilhelmi et al[13] in the American population is applicable to the Brazilian population.

Therefore, this study focused on an evaluation of the length of the A1 pulley and confirmation of the palmar surface parameters proposed by Wilhelmi et al[13] for the exact location of the proximal edge of the A1 flexor pulley in the index, middle, ring, and little fingers.

MATERIALS AND METHODS

This work was approved by the Research Ethics Committee of the Universidade Federal de São Paulo. We studied 70 hands from 35 fresh unclaimed cadavers, 30 males and 5 females. We dissected the index, middle, ring, and little fingers of each hand, making a total of 280 fingers.

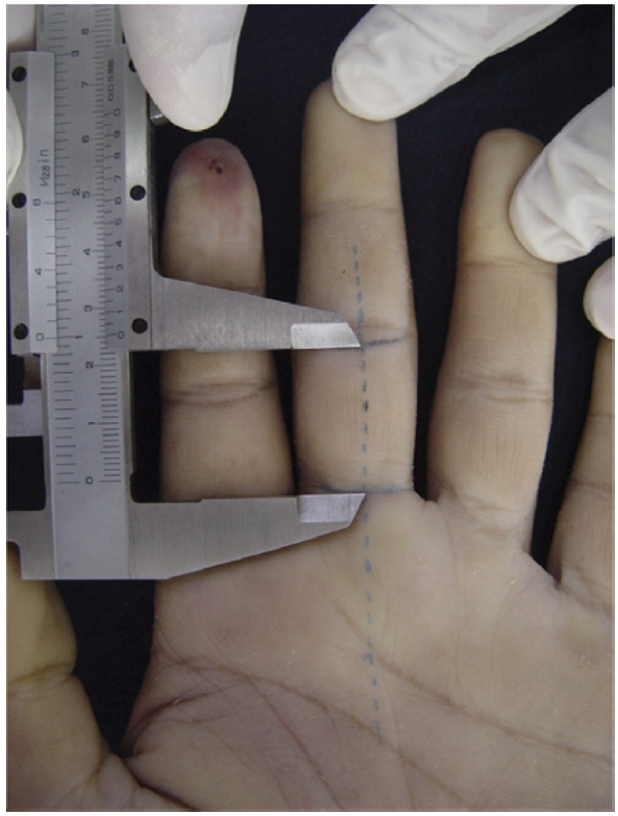

FIGURE 1: Measuring the distance between the digital-palmar and proximal interphalangeal creases.

Initially, we identified the proximal palmar crease, distal palmar crease, digital-palmar creases, and proximal interphalangeal creases of the index, middle, ring, and little fingers, and marked the proximal edge of the digital-palmar and proximal interphalangeal creases with a fine-tip pen.

We then located the midpoint of the distance between the radial and ulnar sides of the fingers on the proximal and middle phalanx, using mechanical calipers with a precision of 100th of a millimeter, to identify 2 points: the first on the proximal phalanx and the second on the middle phalanx. A straight line was drawn, joining these 2 points, corresponding to the central longitudinal axis of each finger. Using mechanical calipers and a ×3.5 magnification lens, we measured the distance between the digital-palmar and proximal interphalangeal creases (measure A) of the 4 fingers, centering the calipers on the longitudinal axis of each finger (Fig. 1).

We then used a needle to transfix the flexor pulley and flexor tendons perpendicularly to the skin at the

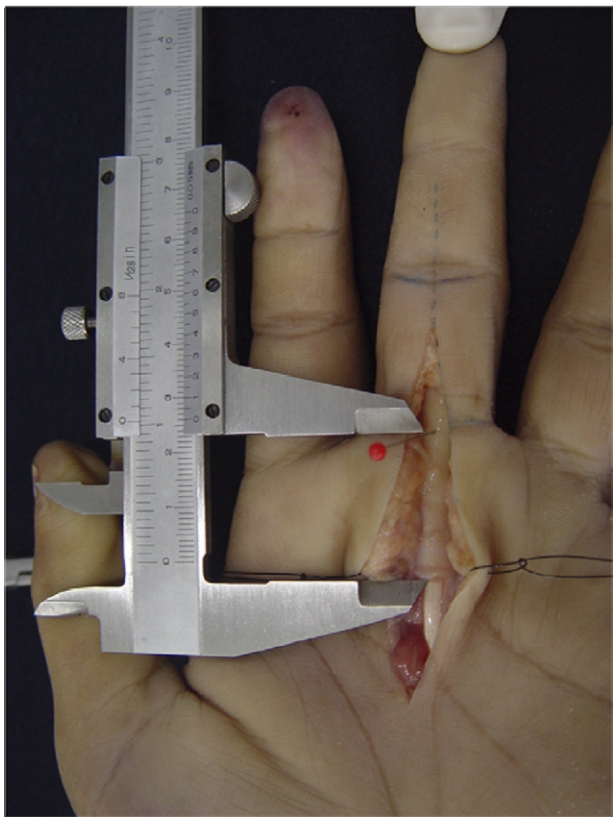

FIGURE 2: Measuring the distance between the digital-palmar crease and the proximal edge of the A1 pulley.

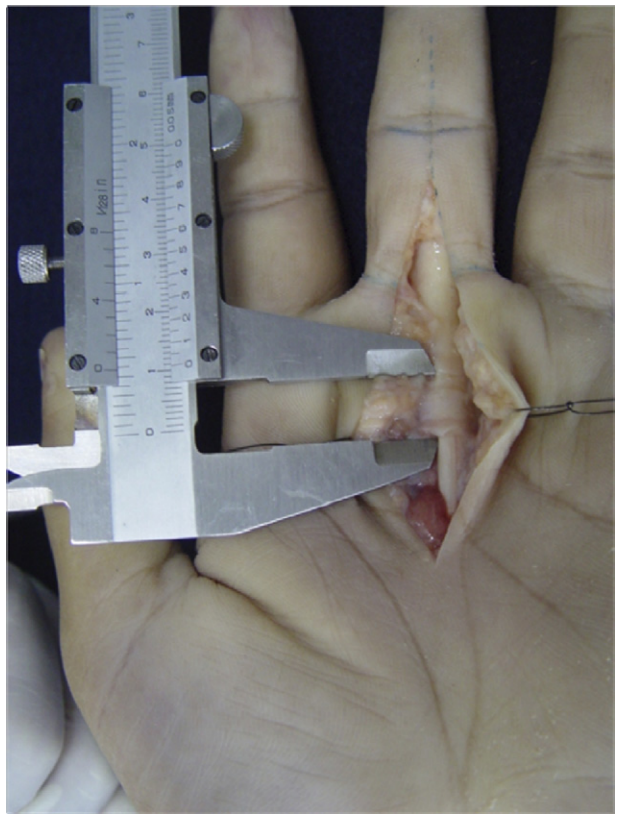

FIGURE 3: Measuring the length of the A1 pulley.

point of the intersection of the longitudinal axis and the proximal edge of the digital-palmar crease, pushing it in until the tip of the needle touched the anterior cortex of the proximal phalanx.

We dissected the fingers using surgical instruments under a ×3.5 magnification lens, incising the finger along its central longitudinal axis, starting 10 mm distal from the digital-palmar crease and extending up to 10 mm proximal to the proximal palmar crease in the index and middle fingers and up to 10 mm proximal to the distal palmar crease in the ring and little fingers, keeping the needle in its initial position. The dissection proceeded until the exact locations of the proximal and distal edge of the A1 flexor pulley were reached. Next, we measured the distance between the proximal edge of the A1 pulley and the digital-palmar crease (measure B) and the length of the A1 pulley (measure C) (Figs. 2, 3).

We used Hotelling's multivariate T^2-test to identify significant differences between measures A and B, and thereby analyze the joint variability in the data. We also used the Student's *t*-test to ascertain equality among the measures corresponding to each finger of both hands. A .05 level of statistical significance was considered significant.

A power analysis indicated that a sample size of 280 fingers would provide a statistical power of 90%, with $\alpha = 0.05$ and $\beta = 0.1$, for a difference of 0.75.

RESULTS

The overall mean length of measures A and B in the index, middle, ring, and little fingers was 21.5 mm for measure A and 21.6 mm for B, with a difference of 0.1 mm between the mean values of the measures.

We calculated the mean and SD of measures A, B, and C of each finger independently of the side (Table 1).

Considering the joint structure of the 8 fingers, the data analysis indicated that there was no statistically significant difference between measures A and B ($p = .715$). Moreover, we found no significant difference ($p > .05$) between measures A, B, and C for each digit matched to the opposite side in each cadaver.

DISCUSSION

The surgical treatment of trigger finger involves the percutaneous or open release of the A1 pulley. With percutaneous releases, there is a risk of not achieving total sectioning of the A1 pulley or of damaging the vascular-nerve bundles or the A2 and palmar aponeu-

TABLE 1. Measures A, B, and C, by Finger

Finger	Measure	Mean (mm)	SD (mm)
Index	A	22.0	2.0
	B	21.9	2.5
	C	9.8	1.3
Middle	A	24.4	2.4
	B	24.2	2.4
	C	10.7	1.2
Ring	A	22.0	2.3
	B	22.3	2.0
	C	9.6	1.1
Little	A	17.9	2.2
	B	18.1	2.1
	C	8.1	1.0

rosis pulleys. It is therefore crucial to identify the exact location of the A1 pulley using palmar cutaneous surface parameters to avoid such complications.

Many papers describe percutaneous release of the A1 pulley in the treatment of trigger finger, but we have found a lack of precise parameters for the surface location of the A1 pulley.[1,2,5]

We believe that although the parameters described by Lorthior[6] provide a general notion of the location of the proximal edge of the A1 pulley, in practice the pulley begins a few millimeters distal from the described landmarks. Barton,[8] Schneider and Hunter,[9] and Strauch and Moura[10] used fixed measures to link the proximal edge of the A1 pulley to the metacarpophalangeal joints of the fingers and obtained diverging measures in their studies, confirming the need to use palmar cutaneous parameters that maintain the proportionality of the measures independent of the population under study.

We consider the parameters used by Nagoshi et al[11] to be imprecise; they do not define the exact location of the A1 pulley because the authors describe it as starting a few millimeters distal from the palmar creases. We believe that the parameters used both by Dunn and Pess[4] and Jongjirasiri[12] may also be imprecise for use in other populations, because they are fixed values and would not be corrected for populations with different hand sizes.

Bain et al[3] performed percutaneous release of the A1 pulley using as cutaneous references palmar surface landmarks similar to those used by Lyu.[7] The authors then dissected the fingers and found that the A1 pulley was not completely released in 32% of fingers. We believe that the low percentage of complete release of the A1 pulley in their study may be attributed to the use of insufficiently precise parameters, and that the use of more precise palmar surface landmarks such as measure A may yield more satisfactory results in percutaneous release with needles. In a recent study on cadavers, Hazani et al[14] used the measure of the distance between the digital-palmar crease and the interphalangeal proximal crease as a surface parameter to locate the proximal edge of the A1 pulley and performed percutaneous release of the pulley. They then dissected the fingers and confirmed the complete release of the A1 pulley in 100% of the cases without damaging the A2 pulley or injuring digital nerves and arteries, thus confirming the efficiency and safety of these surface landmarks.

Seeking to determine whether the surface landmarks described by Wilhelmi et al[13] apply to the Brazilian population, we observed similar results. This relationship seems to us more reliable and accurate than fixed values, and it can be used independently of hand size, because the relationship between these distances does not change, as we observed in our study. It should be noted that the Wilhelmi et al study involved the American population, which is composed basically of whites (75.0%), African Americans (12.4%), Asians (4.4%), and others (8.2%), whereas the Brazilian population is composed of whites (53%), African descent/blacks (44%), Asians (0.4%), and others (2.6%).[13,15–17] Moreover, on average, the American population is about 70 mm taller than the Brazilian population.[15,17,18] Nevertheless, despite these ethnic and anthropometric differences, we found that the relationship between the palmar surface and the proximal edge of the A1 pulley remains constant.

We compared the mean length of the distance between the digital-palmar and proximal interphalangeal creases (measure A) with the distance between the proximal edge of the A1 pulley and the digital-palmar crease (measure B) in the index, middle, ring, and little fingers, and found that Wilhelmi et al[13] showed 24.2 mm for measure A and 24.5 mm for measure B, whereas our study found 21.5 and 21.6 mm, respectively, for measures A and B. This indicates that the hands of the populations involved in the 2 studies had different measures, and undoubtedly different hand lengths.[13]

A limitation of this study is that it was performed on cadavers and required clinical proof of the efficiency of surface landmarks studied.

Although the population of this study presents anthropometric measures that differ from those of the population studied by Wilhelmi et al,[13] because the

mean length of measures A and B and of the pulley differed in the 2 studies, there was no change in the relationship between measures A and B in the 2 studies, indicating that the measure of the distance between the digital-palmar crease and the proximal interphalangeal crease should be used to locate the proximal edge of the A1 pulley, starting from the digital-palmar crease, even in populations whose hands present different measures. Thus, in percutaneous trigger finger release, the edge of the A1 pulley can be marked on the skin surface, ensuring greater safety during the procedure.

REFERENCES

1. Eastwood DM, Gupta KJ, Johnson DP. Percutaneous release of the trigger finger: an office procedure. J Hand Surg 1992;17A:114–117.
2. Pope DF, Wolfe SW. Safety and efficacy of percutaneous trigger finger release. J Hand Surg 1995;20A:280–283.
3. Bain GI, Turnbull J, Charles MN, Roth JH, Richards RS. Percutaneous A1 pulley release: a cadaveric study. J Hand Surg 1995;20A:781–784.
4. Dunn MJ, Pess GM. Percutaneous trigger finger release: a comparison of a new push knife and a 19-gauge needle in a cadaveric model. J Hand Surg 1999;24A:860–865.
5. Sato ES, Albertoni WM, Leite VM, Santos JBG, Faloppa F. Trigger finger: a prospective assessment of 76 digits treated by percutaneous surgery. Rev Bras Ortop 2004;39:309–322.
6. Lorthioir J. Surgical treatment of trigger-finger by a subcutaneous method. J Bone Joint Surg 1958;40A:793–795.
7. Lyu SR. Closed division of the flexor tendon sheath for trigger finger. J Bone Joint Surg 1992;74B:418–420.
8. Barton NJ. Experimental study of optimal location of flexor tendon pulleys. Plast Reconstr Surg 1969;43:125–129.
9. Schneider LH, Hunter JM. Flexor tendons-late reconstruction. In: Green DP, ed. Operative hand surgery. New York: Churchill Livingstone, 1982:1375–1440.
10. Strauch B, Moura W. Digital flexor tendon sheath: an anatomic study. J Hand Surg 1985;10A:785–789.
11. Nagoshi M, Hashizume H, Nishida K, Takagoshi H, Pu J, Inoue H. Percutaneous release for trigger finger in idiopathic and hemodialysis patients. Acta Med Okayama 1997;51:155–158.
12. Jongjirasiri Y. The results of percutaneous release of trigger digits by using full handle knife 15 degrees: an anatomical hand surface landmark and clinical study. J Med Assoc Thai 2007;90:1348–1355.
13. Wilhelmi BJ, Snyder N, Verbesey JE, Ganchi PA, Lee WPA. Trigger finger release with hand surface landmark ratios: an anatomic and clinical study. Plast Reconstr Surg 2001;108:908–915.
14. Hazani R, Engineer NJ, Zeineh LL, Wilhelmi BJ. Assessment of the distal extent of the A1 pulley release: a new technique. Eplasty 2008;22:423–427.
15. U.S. Census Bureau. United States 2000: Summary population and housing characteristics. Available at http://www.census.gov/prod/cen2000/phc-1-1-pt1.pdf. Accessed Aug 18, 2010.
16. Wikipedia. Demographics of the United States. Available at: http://en.wikipedia.org/wiki/Demographics_of_the_United_States. Accessed Aug 18, 2010.
17. Brazilian Institute of Geography and Statistics. Census–2000. General population characteristics: sample results. Available at: http://www.ibge.gov.br/home/estatistica/populacao/censo2000/populacao/cor_raca_Censo2000.pdf. Accessed Aug 18, 2010.
18. Wikipedia. Human height. Available at: http://en.wikipedia.org/wiki/Human_height. Accessed Aug 18, 2010.